A Systematic Theory of Emotion

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Running head: Theory of Emotion

Abstract

A systematic informational framework is used to develop a general theory of emotion. One of the theory's central principles is that each primary form of emotion is sequentially differentiated into at least three distinct components. First, hedonic arousal codes the adaptive significance of primitive stimulation in terms of criteria derived from the species' evolutionary history. Second, associative control codes the adaptive significance of memory traces by reproducing the hedonic changes that were paired with previous trace activation. Third, regulation transmits hedonic information to other psychological structures in ways that facilitate future gratification and need fulfillment. Some forms of emotion also contain an exertion feedback component, which codes the successfulness of ongoing exertion. Another of the theory's central principles is that lateral differentiation generates three forms of pleasure (sentia, effectance, and animation) and four forms of distress (exigeance, noxia, frustration, and fear). Research supporting the theory's analysis of sequential differentiation is reviewed in detail, and the motivational function of fear in active avoidance is analyzed as a general illustration. The theory's antecedents and metatheoretical assumptions are also briefly discussed.

A Systematic Theory of Emotion

Although emotion has been the subject of many significant empirical investigations, it has been slow to gain respectability as a scientific concept. One reason for this failure has been the lingering negative impact from certain early theories. Around the turn of the century, McDougall (1908) and others began proposing long lists of specific instincts (e.g., to take care of children) that were considered capable of explaining all behavior. At about the same time, Freud propounded his momentous but imperfectly documented thesis that sexual and aggressive energies are the central driving force in human behavior. The weaknesses in these influential theories soon fell under severe and justified attack, and some later psychologists tended to become highly skeptical of all attempts to explain behavior in terms of emotion. But this extreme anti-instinctivism was almost as bad as the early theories it replaced because it tended to promote an overly rationalistic view of human nature, as if love and war could be reduced to nothing more than a striving for cognitive consistency.

Recent years have brought substantial progress in establishing a more balanced approach to emotion. Plutchik (1962, 1980) has provided a valuable analysis of the evolutionary forces that influence the development of emotion at the species level. There have also been many important advances in our understanding the physiological bases of emotion, as in the work by Arnold (1960, 1970), Ax (1953), Delgado, 1966, 1971), Gray (1972, 1977), Heath (Heath

& Mickle, 1960), Lorenz (1969), Olds (1965), and Young (1961). Finally, some very useful analyses of emotion have been offered by theorists working on traditional issues in animal learning and motivation. Konorski (1948), for example, has presented some seminal ideas on the excitatory and inhibitory control of unconditioned responses. Others have attempted to explicate the causal relationships operating between stimulus conditions, tissue needs, emotional processes, and motivated responses. Along these lines, Bindra (1974) has proposed that each type of tissue need is related to a distinct "central motive state" (similar to emotion) that sensitizes the organism to need-reducing stimuli and facilitates primitive motor responses directed toward the control of those stimuli. Thus, as expressed in the terminology of the present theory, the pairing of a situational predictor with a hedonic consequator during operant learning produces the expectation that the predictor will be followed by the consequator. Exposure to the predictor then reactivates the cognitive representation of the consequator, which in turn activates the corresponding central motive state and its related motor response. Though essentially agreeing with these principles, Bolles (1972, 1975) has proposed the addition of an expectation cognizing the relationship between the operant response and the consequator.

Despite the value of such contributions, however, the study of emotion continues to suffer from serious theoretical deficiencies. The following observation by Irwin (1971) is as true today as when expressed approximately a decade ago:

like many other theorists, Plutchik has been unable to follow his own definition consistently. Thus he stated elsewhere that the "complex processes of sensory input, evaluation, symbolization, comparison with memory stores and the like, those processes we call cognitive, are in the service of emotions and biological needs" (Plutchik, 1980, p. 295, italics added). Since this implies that cognition is separate from emotion, it contradicts his definition. Another deficiency in his definition is the ambiguity of its individual terms. Does "impulses to action" mean that emotion only influences motor responses? What does "designed" mean? Finally, a more profound deficiency than any of the above is his general failure to fully develop and utilize the sequential analysis hinted at in his definition. Instead, almost all of his theory is devoted to the functions served by the different forms of emotion that he has postulated.

The goal of this article is to rectify many of these problems through the formulation of a systematic general theory of emotion. The theory will attempt to combine the richness of existing work with the explanatory power of a new sequential analysis and the clarity of a thorough integrative reconciliation.
Let us begin with a definition of the key concept.

The Definition of Emotion

Principle 1. Emotion is a neural subsystem that primitively processes information in ways that differentially facilitate adaptive responses in the sensory, memory, and motor subsystems.

The above definition has several significant implications. Foremost is its characterization of emotion as entirely primitive,

which follows the tradition begun by Arnold (1960), Delgado (1966), Izard (1972, 1977), and MacLean (1963, 1977). This premise speaks directly to the long-standing problem of delineating the difference between emotion and motivation. Consider Pribram's (1980) recent statement that "emotional reactions ordinarily 'terminate within the organism's body,' whereas motivations are 'apt to go farther and enter into practical relations with the exciting object'" (p. 251). Although there is some truth to Pribram's conception, it is woefully imprecise in that it makes no clear attempt to specify what is added to emotion to create motivation. Moreover, its emphasis on motivation's transactional function ignores the important fact that intrapsychic defense mechanisms are generally considered to be motivated. Similar difficulties can be found in Plutchik's (1980, pp. 362-363) attempts to grapple with the issue.

By contrast, the definition of emotion presented here facilitates resolution of this problem by suggesting that motivation is the sum of the primitive and associative processes that directly control the execution of programs. Emotion is thus seen as only one of the two major components of motivation, so that a child's motive to hit a playmate might consist not only of frustration but also of the expectation that aggression will relieve the frustration. Since programs can direct intrapsychic processes as well as motor output, this approach permits

a more heuristic conception of motivation.

Another important feature of the above definition is its emphasis on emotion's adaptive functions, which follows in the tradition established by Izard (1972, 1977), Leeper (1948), MacLean (1963, 1977), and Plutchik (1962, 1980). Note that emotion is not posited to be always adaptive, only as generally adaptive (see later discussion). A phenomenon is considered adaptive to the extent that its total benefits for a given biological entity exceed its detriments, while it is maladaptive to the extent that its detriments exceed its benefits. A biological entity can be defined as either an individual or a species, depending on the purpose of one's analysis.

The last major feature of the definition is its conception of emotion as a miniature system in which a certain type of stimulus information serves as input and a certain aspect of response-control serves as output. Although there have been a few attempts to analyze emotion in systems theoretic terms (e.g., Neisser, 1963; Scott, 1980; Simon, 1967; Urban & Ford, 1971), none has been adequate. The present theory proposes that the various processes comprising the emotional system are differentiated in two major ways. Sequential differentiation* provides a set of components that perform different assimilative or expressive functions in a given processing sequence. Lateral differentiation*, on the other hand, provides an array of parallel components capable of

performing different sequences in response to different classes of stimulus information. Systems theory has been extremely valuable both in initially suggesting this conception and later in providing the analytical tools for its elaboration and refinement.

Existing research suggests that each form of emotion is sequentially differentiated into at least three, and in some cases four, distinct components. One component is needed to primitively code the adaptive significance of primitive stimuli. In some emotions there is need for another component that discriminates between successful and unsuccessful exertion at a primitive level. Still another component is needed to express information about a stimulus' adaptive significance in a way that influences future stimulus assimilation. In saying that this componential analysis is supported by research, I do not mean that all of its features have been definitively proven. There are many important points that remain empirically ambiguous. But I believe the analysis in its totality is more plausible than any existing alternative (see further discussion below). The remainder of the article will be organized around the principles of sequential differentiation, with only a brief overview of lateral differentiation.

The Hedonic Arousal Component

Principle 2. The hedonic arousal component of emotion contains pleasures (which primitively code the presence of beneficial stimuli) and distresses (which primitively code the presence of detrimental stimuli.

The hedonic arousal structures primitively code the adaptive significance of stimulation through semi-enduring, simple-discriminative responses.[1] The coding performed by these structures is described as primitive because it is ultimately based on genetic information about stimulus adaptiveness that has been stored over the course of the species' evolutionary development (see Glickman & Schiff, 1967; Plutchik, 1980). The present theory posits that each hedonic arousal structure responds selectively to a predetermined class of primitive stimuli, with a primitive stimulus being defined as one that stimulates a given psychological structure entirely through reflexive pathways rather than through memory traces. The taste of sugar, for example, is a primitive stimulus for simple sensory pleasure. Although the hedonic arousal structures become increasingly controlled by traces as cognitive development progresses, their basic innate pattern of responding is thus postulated to remain constant.

Hedonic arousal is described as semi-enduring because it tends to remain for a for a few seconds or even minutes after the offset of its excitatory stimlus, though at an increasingly diminishing intensity. This feature is justified by the fact that an emotional effect often persists long after its initiating stimulus has been removed, as when an infant remains frightened for a while after hearing a sudden loud noise. Arousal is described as performing simple discrimination because it codes information about the mere

presence or absence of a particular type of stimulus rather than information about a stimulus' sensory qualities.

Any given hedonic arousal structure can receive several distinct types of input and output, as shown schematically in Figure 1. The

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Insert Figure 1 about here.

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individual functions of these processes will become clearer as we examine the other components of emotion. But the following points deserve emphasis here.

The theory posits that the single most significant type of hedonic input is the exteroceptive information conveyed by the sensory channel and that other types of input are either directly or indirectly dependent on such stimulation. This principle is intended as an explicity contrast to the now defunct James-Lange theory (see Cannon, 1929; Primbram, 1980), which posited that emotion was aroused by afferent feedback from autonomic activity. Interoceptive input from the vital organs can probably influence the intensity of hedonic arousal, but it is seen more as an augmenter of the hedonic effects produced by other stimuli than as a primary instigator of hedonic arousal. Because the present article will concentrate on avoidance motivation as a principal illustration of emotional processes, it is particularly interesting to note that research by Wynne and Solomon (1955) has supported this view in the case of fear. They

found that surgical elimination of autonomic feedback impaired but did not eliminate an animals capacity to acquire a conditioned fear response.

In examining Figure 1, one may wonder if the profusion of proposed inputs and outputs precludes a meaningful, deterministic analysis of hedonic functioning. It may be especially disconcerting to entertain the possibility of reciprocal influences between different hedonic structures, since such influences might entail a degree of circular causality that could easily degenerate into chaotic fluctuations. But keep in mind that the entire hedonic function is given considerable coherence by the initial preeminence of sensory input, the orderly growth of associative control, and the broad organizing function of regulative feedback. Moreover, other restrictions to be discussed later will futher reduce the possibilities for indeterminacy.

Overview of Lateral Differentiation

The various forms of emotion can be divided into two general classes according to the nature of their hedonic components. An emotion is defined as pleasurable if it is hedonically aroused by species-adaptive primitive stimuli and if it tends to indirectly facilitate its own hedonic arousal through the types of regulative feedback it evokes. After the odor of a nearby food source has

excited pleasurable arousal, for instance, the regulative feedback generated by this arousal tends to strengthen the original positive stimulation by motivating the organism to approach and eat the food. By contrast, an emotion is distressful if it is hedonically aroused by species-maladaptive primitive stimuli and if it tends to impede its own hedonic arousal. Thus, a distressful response might be aroused by the odor of a poisonous gas, which would cause the organism to withdrawal from the odor and reduce the distress.

The primitive stimuli arousing pleasure and distress are described in terms of their adaptiveness to an entire species rather than to a single organism because, as postulated earlier, the differential hedonic responsiveness of each emotion is seen as determined by evolutionary development. The fact that a certain primitive stimulus has generally been adaptive to a species therefore does not insure that it will be adaptive under the specific conditions faced by a particular member of the species. A prosperous suburbanite may experience considerable pleasure from eating a 12-ounce sirloin steak every night for dinner, even though his resulting overweight and high levels of serum cholesterol may cause him to die prematurely from a coronary attack. At the species level, however, steak has been quite adaptive over the course of evolution because of its high nutritional value. Note that some primitive stimuli

may only mimic the qualities possessed by adaptive and maladaptive stimuli (e.g., saccharine). The above principles of hedonic responsiveness are therefore not completely free from exception even at the species level.

I propose that the lateral differentiation of hedonic structures produces seven distinct forms of emotion, each with its own set of sequential processes. Since space limitations in the present article do not permit a thorough review of the research supporting this facet of the theory, almost all such material will be reserved for a separate publication (Stratil, Note 1).

Sentia. Pleasure is differentiated into three forms. The first, sentia (pronounced as in the Latin word absentia), is aroused by the various types of sensory stimulation that facilitated need-reduction and procreation during the species' evolutionary development. This includes such stimuli as food, water, moderate warmth, and sexual contact. Sentia should be considered a family of emotions, since research (see Cotman & McGaugh, 1980) has demonstrated that the above types of stimuli arouse somewhat separate sets of neuroanatomical structures or nuclei. In essence, then, sentia consists of several classes of emotional sequences that have been grouped together on the basis of their common general function rather than their anatomical features.

Effectance. The second form of pleasure consists of effectance, which is excited by primitive success cues and inhibited by primitive failure cues. This emotion has been proposed by Robert White (1963) in

his prominent theory on the development of competence motivation. He found substantial evidence that infants experience pleasure in using their capacity to control the environment even when no tangible rewards are received. A baby may thus smile when it succeeds in hitting a rattle and hearing the auditory feedback. The present theory will attempt to resolve the traditional problem of conceptualizing this emotion by proposing that a set of special coding structures (see the exertion feedback structures discussed below) generate primitive success and failure cues. These structures essentially code an act's successfulness by comparing the overall levels of gratification that exist at different points in the action sequence.

Animation. The third form of pleasure consists of animation, which is aroused by the mere presence of any type of sensory stimulation (whether intrinsically positive or negative). It can be described as only mildly pleasurable because people often avoid very high levels of it (Berlyne, 1967). This pattern can be explained by positing that animation itself is always pleasurable but that it tends to excite fear at high levels. Animation's primary function is to maintain alertness by transmitting diffuse excitation to many other psychological structures.

Exigeance. Distress is differentiated into four basic forms. The first, exigeance, is aroused by biogenic stimulation indicating increases in various tissue needs (e.g., the need for food and

water). Thus, after an organism has gone sixteen hours without food, it experiences increasing exigeance that can only be relieved by the ingestion of food.

Noxia. The second form of distress consists of noxia, which is aroused by various types of stimulation that have directly caused poisoning and tissue destruction during the species' evolutionary development. Like sentia, it is composed of several distinct subclasses. One of these, repugnance, is aroused by the taste or odor of poisons. Another, pain, is aroused by stimuli that destroy free nerve endings. The general function of noxia is to motivate instinctive escape from detrimental stimuli upon immediate physical contact with them.

Frustration. The third form of distress consists of frustration, which is excited by primitive failure cues and inhibited by primitive success cues. It is thus the opposite of effectance. The primary adaptive function of this emotion is to cause an organism to cease performing responses that are no longer rewarded. Without it, organisms would persist in futile, misguided acts until overcome by exhaustion.

Fear. The fourth form of distress consists of fear, which is excited by primitive danger cues and inhibited by primitive safety cues. Some primitive danger cues consist of sensory patterns that often accompany danger--such as an object making irregular movements (like a snake), an object making a rapid approaching

movement (like a wolf), a relatively large object (like a bull), a loud, irregular, or complex noise (like that emitted by an animal under attack), and a situation manifesting extended vertical depth (like a cliff). Research has shown that all of these patterns possess the capacity to arouse fear even when the organism has not had any prior contact with them (Marks, 1969). Another primitive danger cue may consist of a sudden or intense increase in animation, which tends to exist when an organism unexpectedly confronts a danger against which it must exert a great effort to protect itself. In addition, the arousal of any other form of distress is posited as a special danger cue that activates only the associative control structures for fear. Thus, the arousal of exigeance, noxia, or frustration causes traces cognizing concomitant cues to acquire excitatory associations to the hedonic structure of fear. It is not certain that there are any primitive safety cues, but evidence suggests that the existence of an ongoing pleasurable response may be one. If so, we can expect it to inhibit the fear structures or to initiate inhibitory associations.

Note the difference between fear and noxia. Where fear is aroused by evidence of <u>impending contact</u> with a detriment, noxia is generally aroused by <u>actual contact</u> with such a stimulus. Admittedly, there are some noxious stimuli (e.g., rotten meat) that emit warning cues (e.g., a nauseating odor) capable of arousing

noxia before physical contact with the detriment has been made. But all such exceptions seem to involve odor, which is usually emitted by substances that are relatively near to the recipient. By contrast, fear tends to be primitively aroused by visual and auditory cues, which are usually found at a greater distance from the recipient. The major function of fear is thus to motivate the avoidance of potentially detrimental stimuli without the necessity of immediate physical contact or prior personal experience with the stimuli.

Stimulus Valence

The above distinctions now permit a systematic analysis of stimulus valence, which is defined as a stimulus' capacity to produce hedonic arousal. Valence contains four dimensions--sign, strength, origin, and effectiveness. A stimulus has a positive sign if it produces gratification and a negative sign if it produces disgratification. When a stimulus is both gratifying and disgratifying, it is bivalent. The strength of a valenced stimulus is the magnitude of the hedonic change that it produces. Origin involves the location of the stimulus qualities that produce hedonic arousal. Inherent valence thus results entirely from a stimulus' internal qualities, whereas contextual valence results from the configural integration of the stimulus' own qualities and those of its context. For example, the concept automobile accident has a negative inherent valence, but it acquires a positive contextual

valence when assimilated within the conceptualization I can avoid automobile accidents by driving safely. When a stimulus has been sufficiently assimilated to produce a hedonic response, its valence is considered effective. Otherwise, its valence is only potential. If someone experienced moderate anticipatory pleasure at the sight of a piece of Bavarian cream pie, for instance, the pie would have an effective valence of, say, +2. But if the person did not know of the pie's existence, it would have a potential valence of +2 and an effective valence of 0.

All motivated behavior is directed toward producing changes in hedonic arousal. There are obviously four basic types of hedonic changes that can occur (increases in pleasure, increases in distress, decreases in pleasure, and decreases in distress). For the sake of simplicity, these changes can be grouped into two classes according to their general adaptive significance. Gratification is any increase in pleasure or decrease in distress. These two changes are placed in the same class because they both indicate the presence of an adaptive relationship between an organism and a given stimulus. Disgratification, on the other hand, consists of any decrease in pleasure or increase in distress. These two changes belong to the same class because they both indicate a maladaptive relationship. The above concepts can be illustrated in the following example. As Margaret lunches on pepperoni and sausage pizza, she experiences gratification

because the oral contact with food increases pleasure. After lunch she goes to a physician who removes a painful corn from her foot, which gratifies her by reducing distress. Then, while eating an ice cream cone on the way home from the physician's office, she falls over a pile of garbage and smashes the cone against the sidewalk. This disgratifies her because it takes away the pleasure she was getting from the ice cream. Finally, a careless cyclist disgratifies her by causing her to jump aside and scratch her arm against a nearby rose bush, which produces an increase in distress. Note that in this analysis the ultimate baseline for measuring increases in hedonic intensity will always be quiescence (e.g., the state in which no hedonic activity at all is occurring). The mere continuation of an ongoing response thus constitutes an increase when compared to its ultimate baseline.

The Exertion Feedback Component

Principle 3. The exertion feedback component provides a primitive coding of successfulness by comparing anticipatory gratification with consummatory gratification.

Two of the most important forms of emotion--effectance and frustration--have traditionally been very difficult to explain because of their semi-independence from sensory and biogenic stimulation. One can be frustrated, for example, merely by failing to recall a telephone number. As a solution to this

theoretical problem, I propose that these emotions are controlled by a set of exertion feedback structures that primitively code the degree to which an operant response has succeeded in producing the type of hedonic effect to which it was directed. Exertion can be defined as the expression of a given type of hedonic arousal through regulative impulses that effectively influence the execution of programs previously related to the control of that type of arousal. Since this definition uses several concepts to be developed in other publications (Stratil, Note 2), its precise theoretical implications may not be apparent. Essentially exertion involves "striving" or performing a "goal-directed" response. I am thus proposing that the arousal of effectance and frustration depends on whether a person's striving has produced a hedonic success or a hedonic failure.

Let us now examine some specific hypotheses about the possible mechanisms that might be involved in the coding of such complex hedonic patterns. First we must recognize that success and failure are both defined in terms of a relationship between an initial state and a terminal state. This suggests that success and failure can be coded by comparing the valence of anticipatory arousal (which is the arousal that motivates an operant response) with consummatory arousal (which is the arousal produced as a final consequence of such a response). If a man searches for a particular item of food because he desires the

sentia that eating it will arouse, the sentia motivating his action is his anticipatory arousal. When the action ceases, the sentia prevailing at that time is his consummatory arousal. Of all the various facets of emotion, probably the most difficult to explain is how anticipatory and consummatory arousal can be discriminated from one another. Since they are both hedonic responses, what quality reliably distinguishes them? The solution I have chosen to this problem lies in the information provided by the exertion process. I propose that anticipatory arousal can be reliably identified by the fact that it always exists before or during the performance of an operant response, whereas consummatory arousal always exists after the response has ceased. In other words, the existence of ongoing exertion indicates that the time is appropriate to measure anticipatory arousal, and the cessation of that exertion indicates that the time is appropriate to measure consummatory arousal.

Exertive Tension

On the basis of these premises, the present theory proposes that four separate structures are involved in the coding of an operant response's primitive successfulness. First, a structure is needed to code the occurrence of exertion per se. The activity taking place in this structure will be called exertive tension. As shown in Figure 2, this structure is seen as

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Insert Figure 2 about here.

subject to control by excitatory input from the occurrence of motivated skeletal motor responses (1) and short-term memory responses (2). The reason for using skeletal motor responses as an indicator of exertion is obvious. Motivated short-term memory responses are used because they play an important role in controlling all cognitive activity, so that they should provide relatively reliable information about intrapsychic exertion. Consider, for example, the situation where a mere expectation of gratification leads to the excitation of frustration when that gratification is not actually obtained. Because active expectations are often intentionally held in short-term memory, the present theory suggests that they will automatically excite exertive tension and, hence, the anticipatory hedonic coding controlled by it. A frustration response will then occur when the anticipated arousal is not obtained. Note that the use of exertion in the above terminology remains appropriate even for this relatively passive case since most expectations are produced by a person's striving to accurately anticipate valenced stimulation. The confirmation or disconfirmation of an expectation thus constitutes an instance of successful or unsuccessful exertion, respectively.

Preliminary Hedonic Coding

A second structure is needed to code anticipatory arousal. The present theory proposes that any increase in exertive tension (3) (symbolized as ↑ in Figure 2) sensitizes this structure

in a way that causes it to begin coding the source and intensity of all ongoing hedonic arousal (4). Still another structure is needed to code consummatory arousal. I propose that the latter is sensitized either by a decrease in exertive tension (5), symbolized as ↓, or by input indicating the suppression of skeletal motor responding (6). In both cases, this sensitization causes the consummatory structure to begin coding the source and intensity of all hedonic arousal existing at the time (7). Motor suppression is an appropriate instigator of consummatory coding because of its role in preventing the obtainment of new external rewards. Any motor response that is being suppressed cannot possibly succeed in attaining its goal. Note that this input has been incorporated as a direct excitatory stimulus to the consummatory hedonic coding structure rather than as an inhibitory stimulus to the exertive tension structure in order to allow for the type of conflict in which suppression continues to arouse frustration as long as it exists. If the input from suppression were to inhibit exertive tension, anticipatory coding would soon cease and the output sent to the frustration structures would be transient.

Comparative Hedonic Coding

A final structure is needed to compare anticipatory and consummatory arousal and produce output indicating the degree of primitive success attained from the exertion. When a favorable relationship exists between the two arousals (i.e., when con-

summatory gratification is greater than anticipatory gratification), output from this last structure will indicate primitive success (8). The man searching for food would experience primitive success if he found what he wanted, since his consummatory pleasure would be greater than his anticipatory pleasure. By contrast, when the relationship between the two arousals is unfavorable (i.e., when consummatory gratification is less than anticipatory gratification), the output from this structure will indicate primitive failure (9). The man searching for food would experience primitive failure if he did not find what he was looking for (or a suitable substitute). Note that the magnitude of anticipatory arousal is probably not coded on the same scale as that of consummatory arousal, since anticipatory arousal is necessarily weaker than consummatory arousal in absolute terms due to its dependence on the relatively weak stimulus effects of traces or primitive predictive cues.

Let me emphasize that this model does not propose that the exertion feedback structures are capable of primitively coding the causal relationship between a given exertive response and the gratification produced by that response. Instead, it only proposes that they are capable of coding the temporal relationship between an exertive response of a particular type and a subsequent emotional response of a particular type. An operant response can therefore succeed without producing a primitive success cue if its emotional consequences occur after the exertive tension structure

has lost all information about the response's existence. But these limitations at the primitive level are gradually reduced as cognitive development provides the organism with complex traces with which to code and retain a more sophisticated body of information about exertion.

Intensity of Output

In extending the above principles, the present theory proposes that the intensity of output from the exertion feedback structures depends on two variables. The first variable is the intensity of exertive tension. The more intense is the exertive tension involved in coding the successfulness of a particular response, the more intense will be any feedback produced by the response. The second variable is the magnitude of the discrepancy between anticipatory and consummatory arousal. The intensity of output is posited to increase in direct proportion to the magnitude of this discrepancy. The strength of primitive exertion feedback, then, is a continuous variable that increases in direct proportion to (a) the amount of effort exerted in performing an operant response and (b) the magnitude of hedonic change produced by the response.

The manner in which primitive exertion feedback is sent to the effectance and frustration structures is described more thoroughly in Stratil (Note 1). Briefly, primitive success cues excite effectance and inhibit frustration, whereas primitive

failure cues excite frustration and inhibit effectance. Keep in mind that the exertion feedback structures are not the only psychological means available for coding success and failure. Cognitive traces can also perform that function. The special importance of the former lies in their capacity to code success and failure at an entirely primitive level. One should also recognize that they are the most speculative feature in the present theory. The purpose in proposing them is to provide a plausible hypothesis to explain some currently baffling motivational phenomena.

The Associative Control Component

Principle 4. The associative control component enables traces to acquire hedonic stimulus functions appropriate to the hedonic changes with which they are paired.

At first it might seem unnecessary to propose an emotional component that does nothing but register trace input and transmit it to the hedonic structures. Why not simply propose that traces become directly associated to the hedonic structures? The necessity for proposing this additional component comes from research indicating that the various traces related to a particular hedonic structure do not all perform the same function. The first scientific evidence for this pattern was discovered over fifty years ago by Pavlov (1927), who found that cues predicting the presentation of food caused an increase in salivation and

those predicting the removal of food decreased it. Assuming that salivation is produced by hedonic arousal and that the informational content of the cues is retained by traces, this indicates that traces can have either excitatory or inhibitory hedonic effects. A thorough review of subsequent research on these effects has been presented by Rescorla (1975; 1979).

Konorski (1948) has offered some very useful suggestions for explaining associative excitation and inhibition. He proposed that conditioned and unconditioned stimuli activate separate neural centers and that the center for the unconditioned stimulus gradually comes under the control of excitatory and inhibitory associations from the center for the conditioned stimulus. An excitatory association was thought to develop between pairs of centers that undergo a concurrent increase in activity. By contrast, an inhibitory association was thought to develop between pairs in which one center undergoes an increase in activity at a time when the other undergoes a decrease.

Note that Konorski interpreted his proposed neural centers to be cortical. Following Hammond's (1971) lead, I will depart from this view by positing that the center for the unconditioned stimulus lies partly in the limbic system. Note also that Konorski (1967; 1972) subsequently abandoned his 1948 theory in favor of one base on reciprocal inhibition between antagonistic

primary centers. He argued that the new theory could better explain certain conditioning phenomena, such as the irregular fluctuations in response strength that occur during acquisition and extinction (Konorski, 1972). But Rescorla (1979) has rejected that thesis and argued forcefully for the earlier theory. The present theory's shift of focus to the limbic system is intended to preserve the most plausible features of Konorski's earlier work and yet still resolve the types of problems he addressed in his later work.[2]

With these considerations as background, the present theory proposes the existence of a set of associative control structures that give traces a hedonic stimulus function appropriate to the types of hedonic change with which they are repeatedly paired during activation. If a trace is paired with increases in a particular hedonic response, it will acquire an excitatory function. If paired with decreases, it will acquire an inhibitory function.

The present theory distinguishes between a situational predictor (S), which is a stimulus in an organism's immediate environment that provides information about some other environmental stimulus, and a hedonic consequator (C), which is a stimulus that directly influences hedonic arousal. (These two stimuli are not intended to be mutually exclusive.) The primary targets of associative control are postulated to be traces for primitive hedonic consequators rather than for situational predictor.[3] This assumption is consistent

with the contention of some theorists (e.g., Bolles, 1975; Longstreth, 1971) that traces cognizing predictive stimuli primarily serve an informational "sign-post" function rather than a direct hedonic function. It is also consistent with the fact that even primitive consequators like shock possess certain sensory qualities, such as tingling and temporal discreteness, that can be readily cognized in traces. It may be precisely the lack of such sensory concomitants that prevents intracranial brain stimulation

from producing strong hedonic conditioning (see review by Bolles, 1975). The principal reason why the trace for a consequator is more susceptible to associative control is probably the stronger temporal contiguity between its sensory coding response and subsequent hedonic change. We must recognize, however, that nothing is existing research precludes the possibility of associative control directly operating over traces for situational predictors as well as consequators. Therefore, while arguing that traces for consequators are the primary targets, the present theory accepts the possibility that traces for situational predictors may also receive some direct associative control.

An Empirical Illustration

A classic study of active shock-avoidance offers an excellent illustration of these associative control processes. Rescorla and LoLordo (1965) first trained dogs to avoid shock and then exposed them to Pavlovian conditioning in which two different auditory cues were paired with the presence and absence of shock. During later tests, they found that the cue paired with shock onset produced a substantial increase in the rate of avoidance responding and that the other cue had the opposite effect. The following analysis of this study will be keyed to Figure 3, which presents a schematic description of the pro-

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Insert Figure 3 about here.

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posed associative control structures. Hereafter all primary events will be denoted by upper-case letters (e.g., S) and the traces that cognize information about these events will be denoted by corresponding italicized lower-case letters (e.g., $\underline{s}$). There are two types of Ss. A presence cue, $S^{\bullet}$, indicates the forthcoming occurrence of of some event, while an absence cue, S°, indicates its nonoccurrence. There are also positive consequators, C^{+}s, and negative consequators, C^{-}s.

Consistent with earlier principles, the presentation of shock (see feature 1) during the operant phase of training produced an increase in pain arousal (2), which initiated sensitization (3) of the excitatory register of fear (4). Because the trace for shock sensations, $\underline{c}^{-}$, was active at the same time, an excitatory association (5) developed between $\underline{c}^{-}$ and the register. This association was gradually strengthened with each repetition of the sequence, so that eventually $\underline{c}^{-}$ was able to independently excite a fear response. The animal was then exposed to a Pavlovian phase in which a high-pitched tone serving as $S^{\bullet}$ was paired with a shock C^{-}. This phase produced the trace $\underline{s}^{\bullet}$ and a spontaneous excitatory association between it and $\underline{c}^{-}$. In other words, the animal developed the expectation $\underline{s}^{\bullet} \cdot \underline{c}^{-}$ (6), which denotes that the occurrence of $S^{\bullet}$ is expected to be followed by that of C^{-}. This expectation enabled subsequent presentations of $S^{\bullet}$ to activate $\underline{c}^{-}$ and thereby excite fear (7).

The explanation of inhibitory registration in the Rescorla and LoLordo situation follows an analogous pattern. Since the offset of shock, $\bar{C}^-$, produced a decrease in pain (8), we can infer that this event initiated inhibitory registration (9, 10, 11, and 12) of the unit $\bar{c}^-$. The subsequent pairing of $\underline{\bar{c}^-}$ with the absence cue, S°, then caused a spontaneous excitatory association to develop between the respective traces for these stimuli, resulting in the expectation $\underline{s^\circ \cdot \bar{c}^-}$ (12). A subsequent appearance of S° was then able to activate $\bar{c}^-$ and thereby inhibit the hedonic register of fear (13). As in the case of simpler emotions, these associative control processes can also be initiated by changes in fear's own hedonic arousal (14 and 15).

Other Empirical Support

Even though Rescorla and LoLordo's (1965) findings provide sound general support for the present account of associative control processes, their study does not speak directly to the theory's various subordinate principles in this area. But significant support for these principles can be found in other research. Consider the proposal that associative inhibition is mediated by a special register controlling hedonic arousal. In one study (Rescorla & Holland, 1977), rats were exposed to Pavlovian training in which an initial presence cue $S_1^\bullet$ was paired

with either food or shock as C and S° was paired with the absence of the same stimulus, $\bar{C}$. It was found that S°'s inhibitory effects on the conditioned response (e.g., startle) could be transferred to a second presence cue $S^{\bullet}_{2}$, but only when both $S^{\bullet}$s had been paired with the same C. Since it seems reasonable to assume that the two Cs evoked strong but entirely different types of primary emotional responses, these results suggest that S° interfered with the conditioned response by indirectly or directly inhibiting hedonic arousal rather than through some other means.

Another line of research has supported the premise that the establishment of such inhibition is initiated by decreases in hedonic arousal. At least two studies have shown that an S° occurring in conjunction with the offset of shock becomes inhibitory if the interval before the next onset of shock is uniform and long but not if that interval is variable and sometimes very short (Moscovitch & LoLordo, 1968; Weisman & Litner, 1971). Since one can expect uniformly long periods of $\bar{C}$ to produce the largest and most reliable decreases in C's hedonic arousal, this pattern suggests that hedonic decrease is the major determinant of inhibitory registration. Incidentally, the fact that $\bar{C}$ only established inhibitory registration in these studies when it possessed a reliably long duration also supports the premise that C and $\bar{C}$ are cognized by separate traces.

As an extension of the above principles of associative control, the present theory posits that the strength of associative sensitization varies in direct proportion to the magnitude of the hedonic changes with which it is paired. A small hedonic change thus produces a weak association, while a large change produces a strong one. There are several lines of empirical support for this principle. First, the magnitude of a conditioned cardiac response has been shown to vary directly with the intensity of the shock used as C (Dykman & Gantt, 1959). Second, the inhibitory effect of $\underline{\bar{c}}$, as activated by $\underline{s}^{o}$, appears to increase in direct proportion to the magnitude of the intensity differential between C and $\bar{C}$ during training (see the Wagner and Saavedra study in Wagner, 1971). Third, the duration, as opposed to the intensity, of C does not exercise a very strong influence on the strength of conditioned autonomic responses (Coppock & Chambers, 1959; Wegner & Zeaman, 1958).

One could argue that none of the above research clearly proves the theory's most fundamental principle in this area, namely, the premise that these associative processes control hedonic arousal. Perhaps they operate without any emotional mediation at all. While that argument cannot be conclusively refuted, the fact that all of the unconditioned stimuli employed

in the above research were either shock or food tends to controvert it. Other research has shown that both of these stimuli readily impart motivational control to situational predictors conditioned with Pavlovian procedures (Estes, 1948; Morse & Skinner, 1958; Rescorla & LoLordo, 1965). Let me clarify, however, that the present theory does not posit hedonic mediation as essential to all forms of Pavlovian conditioning. Such a conclusion is definitively precluded by the case of spinal conditioning, where conditioning of a leg reflex can occur after complete severance of the spinal cord (e.g., Patterson, Cegavske & Thompson, 1973).

The Regulative Component

Principle 5. The regulative component controls certain motor reflexes and transmits differential primitive feedback to intrapsychic mediators of valenced stimulation in ways that facilitate future gratification and need fulfillment.

The last primary component of emotion is a set of structures that regulate hedonic arousal and related reflexes. Following some general suggestions set forth by Miller (1963) and Young (1961), the present theory proposes more specifically that the regulative structures use hedonically coded information to selectively modulate other psychological structures in ways that differentially facilitate the assimilation of positive over negative stimuli and the performance of species-adaptive over species-maladaptive motor reflexes. Since regulation is controlled by hedonic arousal, its intensity is posited to be directly proportional to the intensity of its antecedent arousal.

Since the regulation of hedonic assimilation poses a greater theoretical challenge to contemporary psychology than does the regulation of motor reflexes, it will be our primary focus. In this process, the regulative structures are posited to transmit excitatory or inhibitory feedback to those non-emotional structures that mediate the stimulation received by the hedonic structures. In two cases, such feedback has a direct effect on stimulus intensity. Research on the gating process suggests that a sensation's amplitude is modulated at the receptor according to its immediate valence relative to that of other sensations (Hernández-Peón, Scherrer, & Jouvet, 1956). Likewise, regulative feedback can directly modulate the intensity of stimulation coming from memory traces, as when a person's attention is rigidly focused on reassuring cognitions that reduce fear (e.g., Janis & Mann, 1977, pp. 120-129; Lazarus, 1966, p. 109). But there is also a form of assimilative regulation that exercises an indirect rather than direct influence over valenced stimulation. In this case, feedback controls skeletal motor expression in ways that determine the nature of the sensory stimulation presented to the organism's receptors. Sustained regulative excitation of the motor program for bar-pressing, for example, can cause a rat to avoid further exposure to experimental shock by performing the bar-pressing response.

The regulation of hedonic assimilation is schematically

diagrammed in Figure 4. Let us begin on the

Insert Figure 4 about here.

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left side of the figure, which shows a pleasurable hedonic structure and its related regulative structures. When a certain intrapsychic mediator (see feature 1) facilitates an increase in pleasure (2), the related regulative structure (3) codes the occurrence of this gratification and transmits excitatory feedback (4) to the mediator (1). Likewise, when a different intrapsychic mediator (5) facilitates a decrease in pleasure (6), the related structure (7) codes the occurrence of this disgratification and sends inhibitory feedback (8) to the mediator(5). A similar pattern can be observed on the right side of the figure with a distressful hedonic structure. Excitatory regulative feedback is thus sent to mediators of decreased distress, and inhibitory feedback is sent to mediators of increased distress. These complex relationships can be summarized in the following general principle: Excitatory feedback is sent to mediators of positive stimulation, and inhibitory feedback is sent to mediators of negative stimulation.

Although this principle appears to hold without exception to the regulation of memory so long as valence is measured contextually (see following discussion), it may encounter several important exceptions when applied systematically to sensory regulation. For instance, because external danger cues serve an immediate adaptive function in promoting avoidance, their sensory assimilation probably receives facilitative feedback despite their negative valence. Since gating processes are very complicated and as yet poorly understood, I will not attempt a systematic theoretical analysis of them here.

Trace Regulation

There are two reasons for considering memory traces as the most significant intrapsychic mediators of valenced stimulation. First, since some traces possess immediate associations to the hedonic structures and others supply the motor programs that direct the performance of most skeletal responses, they are capable of exercising both direct and indirect control over hedonic assimilation. Second, since memory traces are acquired from individual experience, their regulation is not rigidly predetermined by genetic forces. The combination of these two capacities enables a newly programmed skeletal response with no history of evolutionary function to be strengthened ("reinforced" in the Skinnerian sense) by its pairing with personalized contingent gratification. No specific premises will be advocated here about the nature of the mechanism that controls the direction of regulative

feedback. But one can briefly speculate that the mechanism might be based on a process that reduces the threshold of active traces in a way that makes them differentially sensitive to regulative feedback or on a retrieval cue that supplies information about the type of hedonic response to which a trace's activation has been previously related. Because of trace regulation's unique importance, it will be accorded some terminological distinctions. The excitatory process by which regulation intensifies the activity of a trace will be called surtainment, while the inhibitory process by which regulation reduces the activity of a trace will be called repression.

A recent review of a wide range of research (Matlin & Stang, 1978) has found very strong support for the general positive bias in cognition implied by this conception of trace regulation. For example, people use positive words more frequently than negative ones, they judge positive objects to be larger than negative ones, they recall positive items more accurately than less positive ones, and tend to put positive items first in a list. Even so, we must recognize that a trace's inherent valence by itself does not necessarily provide enough information to predict the type of regulation it will receive. One cannot conclude that all traces with a negative inherent valence, for example, will always be repressed. Such a conclusion would be clearly absurd in light of the fact that people sometimes dwell quite intensely on negative cognitions. Instead, we are led

to conclude that a trace receives a type of regulation appropriate to its contextual valence as determined by its relevance to all other active traces. Thus, despite the almost universal negativity of the concept automobile accident, it will probably receive surtainment within the positive formulation I can avoid automobile accidents by driving safely. In general, then, the regulative structures excite and inhibit individual traces in a way that optimizes the net valence of all active traces taken as a whole.

An illustration of this principle can be found in the regulation of traces for failure. Other things being equal, a trace cognizing a personal academic failure would be repressed. But if the person possesses a strong positive value for prudence, he or she will probably think about the failure in the context of other traces that cognize acts that could be performed to avoid a repetition of the failure. In other words, the gratification the person obtains from his or her sense of prudence in realistically facing the failure may override his or her desire to ingore the failure. In support of this application of the principle of contextual valence, a study by Lazarus and Longo (1953) found that individuals showed consistent differences in their styles of assimilating threatening information about failure. Some were prone to facilitate such assimilation, while others were prone to impede it. As suggested above, one can hypothesize that

the facilitators incorporated the threatening information into a broader cognitive network possessing a positive valence.

The Empirical Status of Repression

Holmes's Critique. Although the present paper cannot examine all of the theoretical issues related to trace regulation, the long-standing controversy over repression deserves special consideration. Of recent prominence in this controversy is Holmes's conclusion that "there is no consistent research evidence to support the [repression] hypothesis" (Holmes, 1974, p. 649). Bear in mind that the vast majority of the studies he reviewed were consistent with the repression hypothesis in the sense that they reported an impairment in the retention of threatening material. His major argument was that all of this research suffers from methodological flaws that raise serious doubts about its validity. For example, a principal focus of his critique was on a series of studies that had attempted to demonstrate repression by pairing words or nonsense syllables with an intense C^- like task failure (e.g., Zeller, 1950, 1951). Although this method found a selective recall decrement for threat-associated stimuli, later research has shown that a similar decrement can also be produced by using a C^+ rather than a C^- (Holmes, 1972; Holmes & Schallow, 1969). Holmes (1974) correctly concluded that this finding raises the strong possibility that subjects in the earlier studies were merely distracted by C^- and that no repression was

involved.

Refutation. But, however cogent Holmes's criticism of this particular paradigm may be, the remainder of his review has dubious validity. He repeatedly dismissed findings that, though not conclusive, nevertheless provide relatively strong support for the repression hypothesis. Buss and Brock (1963), for example, found that recall varied as a function of experimentally induced threat to self-esteem. Using a forced-compliance paradigm, subjects opposed to the use of electric shock in psychological research were exposed to an authoritative message describing the laboratory administration of shock as either very dangerous or very safe. Subjects in the experimental condition were then pressured into administering shock to another subject, while those in the control condition were given a neutral experience. The results showed that recall of the shock-is-dangerous message was substantially lower in the experimental as compared to the control group. Apparently, the counterattitudinal act of administering shock enhanced the threat presented by the shock-is-dangerous message, causing subjects to use repression to impede its reassimilation. Holmes attempted to dismiss the significance of this study by arguing that the experimental group's inferior recall may have been due to the less favorable physical surroundings in which they read the message (in front of distracting scientific equipment as opposed to the more familiar

background of a quiet college classroom). But this argument is untenable because the two groups showed no difference in their recall of the shock-is-safe message.

In another plausible study of experimentally induced threat, Truax (1957) divided a group of subjects into defensive constrictors and defensive vigilants according to a self-report measure of personality[4]. After then having them learn a list of paired-associates to a standard level of proficiency, he exposed them to a failure experience in which the section headings of an intelligence test were identical with some of the words in the paired-associates list. He hypothesized that threat from the failure would only generalize to the overlapping words, which in turn would produce selective repression of the latter. This hypothesis was confirmed for the constrictors, whereas the vigilants showed the opposite pattern. Since all subjects were exposed to the same threat-induction (i.e., task failure), one cannot argue that the selective decrement in retention was caused by general distraction. Holmes did not explicitly reject the validity of this study, but he tried to cast a global pall of suspicion over it by raising a series of weak criticisms.

The full theoretical significance of Truax's (1957) study goes beyond merely supporting the basic repression hypothesis. His work suggests that individual differences in defensive style must be properly considered in any meaningful investigation of repression. Since the constrictors and vigilants responded

to the threat material in a directly opposite manner, Truax clearly would have found no evidence of repression had he not introduced this personality variable into his study. I believe that a strong argument can be made that many of the studies (e.g., Grummon & Butler, 1953; Merrill, 1952) that have failed to confirm earlier reports of repression have done so for exactly this reason. An original study may accidently obtain a sample containing a disproportionate number of constrictors, while its follow-up studies may contain a more normal balance of constrictors and vigilants. In examining the overall pattern, reviewers have naturally concluded that the original study was simply a fluke. But in fact it may have validly demonstrated repression for individuals possessing a constrictive personality. Recently, Heilbrun (1973, 1978) has had considerable success in developing a perceptual measure of constrictive tendencies based on the threat of social rejection. This kind of work opens up important new avenues for further explicating the interaction between situational repression and defensive style. Instead of contradicting the repression hypothesis as Holmes contended, this interaction is merely an example of the general principle that trace regulation depends on the trace's contextual rather than inherent valence.

In assessing whether existing research has given the repression hypothesis an adequate test, one should also keep in mind the relatively weak threat that has too often been used. The stimulus

materials have frequently been nonsense syllables and single words, which, as Holmes admitted, has limited the experimental testing of Freud's hypothesis to conditions that are quite different from those where it was intended to apply. The concept of repression was formulated as an explanation for the way certain psychotherapy patients cope with the complex threats in everyday life--such as parental rejection or abuse, forbidden affectional desires, jealousy, and so forth. Such stimuli probably elicit relatively powerful and distinctive evaluative responses, which, according to present theoretical principles, should be readily controllable through emotional regulation.

There is one study that surpasses even Buss and Brock (1963) in the potency and ecological validity of its threat. Wilkinson and Cargill (1955) presented a group of college students with the following brief story containing vividly threatening sexual symbolism:

> The oddest thing happened the other night. I had a dream that didn't make any sense to me. Late in the evening before retiring, I had received a telegram saying that mother had been in an accident. After this I was very worried and had a difficult time going to sleep. In my dream it seemed I was again a little boy and was home walking around. I wandered from room to room. Suddenly I opened a door and there was mother's room. I was cold. I got into

the nice warm bed with mother. She smiled, put her arms around me and drew me close to her warm body. Her soft skin felt good against my warm body. Everything changed. I can't remember just how. The next thing clear to me was the sensation of climbing a long stairway up a hill to the beautiful temple situated on top. The stairs led to the temple door. All around the temple were shrubs, trees, and heavy foliage. I climbed the stairs, reached the door and opened it. I awoke with a start and found myself shaking and perspiring as from great excitement. I realized that it was the ringing bell that woke me. It was the phone and it was still ringing. I jumped from bed, answered it only to hear mom's voice telling me everything was all right and she had not been hurt.

Whether or not one fully accepts Freud's theory of the Oedipus complex, the incestuous mother-son sexual theme of this story can certainly be expected to arouse intense anxiety in most male subjects from our culture. The control group was shown a very similar but less threatening story about a brother and a beautiful lake in a vast desert. Results from a retention test showed that the males suffered a 37% disadvantage in their recall of the threatening story as compared to the nonthreatening story. Yet the women experienced a 6% advantage in this same comparison. We thus have some relatively strong additional support for the repression hypothesis.

Future Directions. Holmes justly criticized the design of the Wilkinson and Cargill (1955) study for not providing a means of ascertaining whether the defensive process occurring during acquisition or retrieval. Only the latter would be a clear demonstration of repression. But what seems equally significant to me is the fact that this highly provocative study has not been repeated and improved upon in the long period following its publication. One could easily have required mastery of each story by means of the serial anticipation method, using sentences or phrases as units. A delay of a week or more in testing would then have provided an opportunity for differential repression without distraction from recent threat inducement. Better yet, one could have developed entirely new materials that allowed the threat to be induced inferentially after acquisition was complete (e.g., through differential identification with a stigmatized central character).

At one point Holmes said that "if all of the previous research is excluded, there are very few, if any, possibilities left for the [experimental study] of the concept" (Holmes, 1974, p. 651). After taking into account the above suggested improvements to the Wilkinson and Cargill (1955) study, which are by no means especially innovative by the broader standards of contemporary human psychology, Holmes's conclusion is clearly false. More generally, the fact that social psychological methods of inducing

threat (e.g., Buss & Brock, 1963) have not been explored more thoroughly testifies to the narrow methodological philosophy that has prevailed in most repression research. All things considered, the repression hypothesis has stronger experimental support and greater possibilities for definitive future support than Holmes's review suggests.

Motor Reflex Regulation

It has long been recognized that emotions exercise a decisive influence over many reflexive motor responses. Some developmental research by Ball and Tronick (1971) and Dunkeld and Bower (Note 3) provides an excellent illustration of this principle. When very young infants were exposed to stimuli that appeared to be objects approaching them on a collision course, they responded with lateral head movements, elevation of the arm as if to ward off a blow, and cries of distress. These defensive responses did not occur when the stimuli appeared to be approaching on a bypass course, which indicates that they were partly mediated by the primitive sensory coding of a specific pattern of visual danger cues. Together, the involvement of danger cues, the defensive nature of the head and arm movements, and the vocal manifestations of distress suggest that fear may have played a key role in mobilizing this behavior pattern.

Nevertheless, I wish to make clear that the present theory sets forth no universal principle regarding the necessity of emotion in skeletal responses. It accepts the possibility that some reflexive responses are mediated entirely by emotion, that others are mediated entirely by primitive pathways leading directly from the sensory register to the motor register, and that still others contain a combination of both types of central mediation. In cases like the above, where a general emotional response accompanies a highly specialized skeletal response, the latter hypothesis appears the most plausible (see also Rescorla & Holland [1977]).

The biological functions of reflexive motor regulation are well documented, especially for the autonomic system (e.g., Cotman & McGaugh, 1980). Several researchers have also found evidence that emotional reflexes contribute to effective social communication (Clynes, 1980; Eibl-Eibesfeldt, 1980; Scott, 1980). Since the regulation of all reflexes is based on primitive information, the present theory assumes that all reflexes serve some adaptive function at the species level (e.g., salivation facilitates digestion). I have nothing to add to existing accounts of such phenomena, so they will not be elaborated upon.

An Example of Integrated Emotional Processing: Shock-Avoidance

In an effort to better understand how the three primary sequential processes relate to one another, let us systematically apply the present theory to the entire Rescorla and LoLordo (1965) shock-avoidance experiment that was briefly examined earlier.

(The exertion feedback process is omitted here because it is only involved in effectance and frustration.) Recall that the animals were first taught to avoid shock by jumping from one side of a shuttle box to the other. Consistent with Seligman and Johnston's (1973) cognitive theory, I will assume that this operant training induced the simple expectations that no-jumping was followed by shock (i.e., $\bar{r} \cdot c^-$) and that jumping was followed by no-shock (i.e, $r \cdot \bar{c}^-$). These expectations are shown in features 1 and 2 of Figure 5. The principles of associative control suggest that the

Insert Figure 5 about here.

operant training also produced an excitatory hedonic association (3) to c^- and an inhibitory hedonic association (4) to $\bar{c}^-$. In one part of the subsequent Pavlovian phase of training, $S^\bullet$ was paired with C^- (5) in such a way as to produce the expectation $s^\bullet \cdot c^-$ shown in feature 6.

The Motivational Function of Situational Predictors

The present theory argues that this training caused a specific sequence of events to occur during the subsequent test phase. First, the reappearance of $S^\bullet$ reactivated the expectation $s^\bullet \cdot c^-$, which in turn produced an increase in fear arousal (7) through its excitatory hedonic association. The increase in fear then caused surtainment (8) to be transmitted to the positive expectation $r \cdot \bar{c}^-$ (note that repression is omitted from this analysis for the sake of simplicity). This caused r to become sufficiently active to facilitate execution of the operant avoidance response R (9) and caused $\bar{c}^-$ to

produce a temporary decrease in fear arousal (10). Each reappearance of $\dot{S}$ elicited a recurrence of the sequence, so that eventually $\underline{\dot{s}}$ became directly associated to the expectation $\underline{r \cdot \bar{c}^-}$, as shown in feature 11. This association enabled $\dot{S}$ to senstize the expectation in a way that facilitated avoidance responses even when fear arousal was relatively low (but not completely absent).[5] Note also that since long delays in performing R during training tended to be followed by C^-, the preexisting expectation $\underline{\bar{r} \cdot c^-}$ was gradually strengthened and associated as a whole (12) to $\underline{\dot{s}}$. This process enabled motor feedback indicating $\bar{R}$ (13) to more readily activate that expectation and thereby maintain a level of fear adequate to motivate reliable avoidance in the presence of $\dot{S}$.

One of the most significant features of this account is the complexity of the memory processes that it posits. If $\underline{\dot{s}}$ and $\underline{\bar{c}^-}$ had been directly associated in such a way that activation of $\underline{\dot{s}}$ could have automatically activated $\underline{\bar{c}^-}$, then the appearance of $\dot{S}$ would have inhibited fear and thereby reduced, rather than intensified, the motive for R. Such an anomaly has been avoided by positing that activation of $\underline{\dot{s}}$ merely sensitized $\underline{r \cdot \bar{c}^-}$ without fully activating it. More formally, one can say that $\underline{\dot{s}}$ joined with $\underline{r \cdot \bar{c}^-}$ to form the conditional expectation $\underline{\dot{s}:r \cdot \bar{c}^-}$ (viz., given $\dot{S}$, R will be followed by $\bar{C}^-$). According to this view, $\underline{\bar{c}^-}$ became hedonically functional only when its partner unit $\underline{r}$ was concurrently activated by some additional source of excitation. In the above case, that

additional excitation was provided by regulative feedback from the fear arousal excited by $\underline{s^{\bullet}}$'s association to $\underline{c^{-}}$.

One may wonder why fear's regulative feedback was not transmitted directly to $\underline{\bar{c}^{-}}$ instead of to $\underline{r \bullet \bar{c}^{-}}$. The basic answer is that the contextual valence of $\underline{\bar{c}^{-}}$ alone was not as positive as the contextual valence of $\underline{r \bullet \bar{c}^{-}}$. The latter should have had a greater net capacity to reduce fear, and hence a stronger positive valence, because it conflicted cognitively with the fear-exciting expectation $\underline{\bar{r} \bullet c^{-}}$. This is only a preliminary explanation, however, since it obviously raises additional theoretical questions regarding the nature of cognitive conflict. Such questions will be addressed systematically in a forthcoming theory of interpretive judgment (Stratil, Note 2).

Although ignored so far in our analysis, the absence cue also played a very important role in Rescorla and LoLordo's study. As shown in Figure 6, the pairing of $\overset{o}{S}$ (see feature 1) with the absence of shock (2) during the Pavlovian phase produced the expectation $\underline{\overset{o}{s} \bullet \bar{c}^{-}}$ (3). Since the unit $\underline{\bar{c}^{-}}$ possessed an inhibitory association to fear arousal (4), the reactivation of this expectation by $\overset{o}{S}$ during the test phase produced a decrease in R-facilitating surtainment (5). That decrease then lowered the frequency of R and raised the frequency with which $\bar{R}$ (6) was paired with $\bar{C}^{-}$ (2). The $\bar{R}$—$\bar{C}^{-}$ pairings in turn established the expectation $\underline{\bar{r} \bullet \bar{c}^{-}}$ and associated it to $\underline{\overset{o}{s}}$, as shown in feature 7 and 8 respectively. Eventually,

Insert Figure 6 about here.

the expectation $\underline{\bar{r} \cdot \bar{c}^{-}}$ acquired the capacity to draw all residual surtainment (9) away from $\underline{r \cdot \bar{c}^{-}}$ whenever S^{o} was present, which caused R to cease completely.

In general, then, the present theory has proposed a complex motivational function for memory in which traces for situational predictors combine with traces for responses and consequences to form internally differentiated compounds capable of exercising multiconditional control over hedonic arousal and providing flexible channeling for regulation. In arguing that regulative feedback was largely channeled through memory in the Rescorla and LoLordo (1965) study, however, I do not wish to suggest that reflexes played no role at all. The initial response of running to escape shock can probably be considered a species-specific defense reaction (Bolles, 1975), which means that initial regulative control over the motor register was channeled largely through reflexive pathways. But as the animals learned to vary their avoidance behavior in accordance with situational predictors, the channeling of regulation was taken over increasingly by memory traces. Nevertheless, some theorists might question the high degree of plasticity implied by the present theory. Bolles (1975), for example, has argued that all shock avoidance in the rat is ultimately mediated by defensive reflexes. Traces simply acquire the capacity to substitute for C^{-}

as an evoker of the reflex. But even if one fully accepted Bolles' position, which I do not, one could argue that regulation controlled the activation of these reflex-related traces in the rat. More importantly, however, I would like to emphasize that the present theory has been designed to generalize to a broad range of species. Indeed, even though much of the well controlled research bearing on the basic issues raised by the theroy has dealt with rats, the theory's intended domain of principal application is the primate. It is therefore important to note that research has clearly shown that arbitrary, non-reflexive behaviors can be readily learned as avoidance responses in monkeys (Lockard, 1969) and humans (Ayllon & Michael, 1959; Feldman & MacCulloch, 1965).

The Issue of Fear Attenuation

Although Seligman and Johnston (1973) have contributed several significant points to this analysis, they adopted one premise that I believe is quite erroneous. Early versions of two-process avoidance theory (Mowrer, 1947; Solomon & Brush, 1954) had argued that avoidance was motivated by the fear-reduction resulting from termination of $S^{\bullet}$. One of the major challenges to this theory has been the fact that the intensity of fear often declines sharply during the later phases of shock-avoidance learning (Black, 1959; Brady, 1965; Brady & Harris, 1977; Coover, Ursin, & Levine, 1973 ; Kamin, Brimer, & Black, 1963). Critics have questioned how fear at such low levels could effectively motivate avoidance. Joining these critics, Seligman and Johnston proposed that fear merely elicits avoidance as a primitive defensive response during the early phases of learning. Later avoidance is then maintained by the expectation $\underline{r \cdot \bar{c}^-}$ and the preference for $\bar{C}^-$ over C^-.

There are at least two serious defects in Seligman and Johnston's approach to this issue. One problem is their failure to offer a systematic explanation of how expectations and preferences actually control response performance. As they themselves acknowledged, their theory simply asserted by "fiat" that these components produce such control. Their key motivational construct, preference, was thus left hanging in mid-air as an arbitrary,

disembodied causal determinant. Another problem is the convoluted logic that they were forced to follow in trying to reconcile their major premise with the fact that the latency of a typical well-established avoidance response is much shorter than the interval between $S^{\bullet}$ and C^{-}. They began sensibly enough by arguing that fear reduction can be considered a consequence of R, that no fear is preferred to fear, and that only rapid Rs produce no fear. Then, in a remarkable twist of reasoning, they argued that the expectations $\underline{r \cdot \bar{c}}^{-}$ and $\underline{\bar{r} \cdot c}^{-}$ and the preference for no fear jointly "produce" rapid avoidance but that fear-reduction plays no "reinforcing" (motivational?) function either in this process or in the instigation of avoidance itself. It seems highly unlikely to me that fear could promote rapid performance of a well-established avoidance response in this way and yet remain non-motivational in any meaningful sense.

These explanatory gaps and enigmas in Seligman and Johnston's theory might be justified if no fear-reduction theory could offer a plausible account of the attenuation of basal fear that is observed in well-trained subjects. But the present theory offers a satisfactory resolution to that problem. It argues that base levels of fear should gradually decline over trials as the subject becomes increasing successful in controlling fear through behaviorally maintained expectations of safety (see also Mackintosh, 1974; Martin, 1961). In the Rescorla and LoLordo situation, for example, each successful

avoidance response can be seen as having increased the internal strength and fear-inhibiting capacity of the expectation $\underline{r \cdot \bar{c}^-}$. If this hypothesis is accurate, then one can argue that $\underline{r \cdot \bar{c}^-}$ exercised a strong chronic inhibitory effect on fear that continually conflicted with the chronic excitatory effect produced by the expectations $\underline{s^{\bullet} \cdot c^-}$ and $\underline{\bar{r} \cdot c^-}$. In other words, low fear was caused by conflicting associative tendencies toward hedonic arousal rather than by decrements in the strength of the association between $S^{\bullet}$ and hedonic arousal (as Seligman and Johnston appeared to argue). This explanation demonstrates the basic plausibility of the present theory's premise that an animal can possess a strong enduring fear-based motive for avoidance despite relatively low levels of actual fear arousal during most of the avoidance sequences. While the theory would still require a non-zero level of residual fear arousal for stable shock-avoidance, Mineka (1979) has observed that no study has yet shown such avoidance without at least some fear.

There are various lines of empirical support for the present theory's explanation of fear attenuation. A study by Feldman (1976, Exp. 4) has shed added light on the fear-inhibiting function of the expectation $\underline{r \cdot \bar{c}^-}$. After causing a stimulus to become an S° by pairing it with shock offset, he found that acquisition of a shock-avoidance response was facilitated by presenting this S° as feedback for successful avoidance. According to the principles of associative control, the pretaining's major effect should have been to establish a fear-inhibiting trace for $\bar{C}^-$ (shock offset) and to associate it to

the trace for S°. The subsequent facilitation that S° exercised on avoidance learning can therefore be attributed to S°'s capacity to reactivate this fear-inhibiting trace. More specifically, S° should have facilitated development of the critical expectation $\underline{r \cdot \bar{c}}^{-}$ by reactivating the prepotent component $\underline{\bar{c}}^{-}$ in conjunction with $\underline{r}$.

A very important study by Starr and Mineka (1977) nicely dovetails with Feldman's research. In Experiment 1, these investigators compared fear levels under three avoidance-like conditions. One group of animals received regular signalized avoidance training to a criterion of either 3, 9, or 27 successful trials. A fully yoked group was exposed to the same pattern of stimulus events as the first group ($S^{\bullet}$ sometimes followed by C^{-}, with a gradually decreasing frequency of C^{-}), but it performed no avoidance responses. Finally, a partially yoked group was exposed to only the $S^{\bullet}$—C^{-} pairings received by the first group (i.e., all cases of $S^{\bullet}$ alone were eliminated). The study found that fear levels in the first group declined in proportion to the extent of avoidance training, replicating the usual fear attenuation effect. The fact that no such decline occurred in the fully yoked group, which received the same number of Pavlovian acquisition pairings ($S^{\bullet}$—C^{-}) and extinction pairings ($S^{\bullet}$—$\bar{C}^{-}$), demonstrates that the decline was not due to the Pavlovian extinction of $S^{\bullet}$'s fear-exciting capacity. Moreover, even though the Pavlovian hypothesis would argue that the fully yoked group should have shown less fear than the partially yoked group

due to its greater exposure to $S^{\bullet}$—C^{-}, no such difference was found.

Reasoning that the only significant stimulus difference between the regular avoidance group and the partially yoked group was the former's exposure to R-feedback, Starr and Mineka performed a second experiment that manipulated such feedback. One group received regular training in signalized avoidance that was supplemented with a special feedback cue added after R. A fully yoked group received the same pattern of $S^{\bullet}$, special R-feedback, and C^{-}. Finally, a partially yoked group received the same pattern of $S^{\bullet}$ and C^{-} but received no exposure to R-feedback. The results showed that fear attenuation occurred in both groups receiving special R-feedback but not in the partially yoked group. Since the special R-feedback can be interpreted as performing a stimulus function equivalent to that of regular R-feedback, the former should have strengthened the fear-inhibiting expectation $\underline{r \cdot \bar{c}^{-}}$. The major finding of this study thus adds further support to the present theory's premise that fear attenuation results from $\underline{r \cdot \bar{c}^{-}}$ rather than from the Pavlovian extinction of $S^{\bullet}$. At the same time, it directly contradicts Seligman and Johnston's theory because of the latter's reliance on the Pavlovian hypothesis.

Continuing with this line of analysis, the present theory argues that any manifestation of $\bar{R}$ should re-excite fear by activating the parallel expectation $\underline{\bar{r} \cdot c^{-}}$. Two studies have found possible support for such an inference. Solomon and Wynne (1954) observed a resurgence

of fear during long latency responses. Similarly, Kamin et al. (1963) found that fear intensified as the frequency of R decreased during the shift from avoidance acquisition to extinction. These data are ambiguous on the finer issues at hand because they do not indicate whether the resurgence of fear was mediated by disconfirmation of the fear-inhibiting expectation $\underline{r \cdot \bar{c}^-}$, by the direct excitatory effects of $\underline{\bar{r} \cdot c^-}$, or both. But they nevertheless demonstrate strong support for the more fundamental principle that the underlying fear response was still strong despite a prolonged absence of shock. In other words, there was little or no extinction of fear.

The overall plausibility of the present account of fear attenuation can also be strengthened by intuitive analysis of a common human avoidance response. Personal observation suggests that most drivers are able to maintain a relatively low level of fear by staying on the right-hand side of two-lane highways, but their fear suddenly increases when they move into the left lane. Surely the driver who never crosses into the left lane has not lost his or her fear of head-on collisions. Instead, it seems more likely that he or she has learned to control that fear by remaining in the safer lane. Driving on the right can thus be conceptualized as a well established avoidance response that activates the fear-inhibiting expectation $\underline{r \cdot \bar{c}^-}$. So long as that expectation is predominant, fear arousal remains low.

Fear vs. Effectance

One of the complications of the present theory is that its principles of lateral differentiation suggest that well established shock-avoidance could be motivated by effectance-enhancement as well as fear-reduction. Thus, the primitive success cue generated by the successful avoidance of pain could establish an excitatory association between effectance and a new trace, $\underline{c}^+$. Repeated pairing of R with $\underline{c}^+$ could then promote the expectation $\underline{r \cdot c}^+$, which would transmit surtainment to the program for R. In this way, avoidance motivation might be maintained without fear.

But there are both empirical and theoretical reasons for arguing that fear is the critical emotion in shock avoidance. LoLordo (1967) has shown that presentation of an $S^\bullet$ indicating onset of a loud noise increases the rate of ongoing shock avoidance and that Pavlovian extinction of the $S^\bullet$ then produces a return to baseline avoidance. This finding implicates the involvement of fear because the most significant commonality between shock and sudden loud noise is their capacity to serve as primitive danger cues. The present theory would thus argue that $S^\bullet$ increased the rate of shock avoidance by intensifying the fear that was motivating that response.[6] Conversely, Canon and Houser (1978) have shown that active avoidance is weakened by anxiolytic (i.e., fear-reducing) drugs but not by nonanxiolytic drugs. In addition to implicating fear as the principal emotion in shock avoidance, note that these studies also are

quite damaging to Seligman and Johnston's premise that fear-reduction plays no significant function in motivating well-established avoidance behavior. In both cases the key manipulation of fear was introduced after acquisition had been accomplished. The observed motivational effect of anxiolytic drugs, for example, contradicts their implied prediction that such manipulations would impair only the acquisition, not the maintenance, of avoidance behavior (Seligman & Johnston, 1973, p. 96).

There are three theoretical reasons for believing that effectance-enhancement is secondary to fear-reduction in motivating shock avoidance. First, the extremely high primitive potency of shock as a danger cue suggests that it should predominate over avoidance as a safety cue. Whereas the mere presence of shock automatically sensitizes fear, the capacity of successful avoidance to sensitize effectance depends on a much more delicate and easily disrupted confluence of coding events. Second, an elaboration of the present theory (Stratil, Note 1) argues that fear's arousal component remains active for a longer period of time after the offset of excitation than does the arousal component of the other emotions. Thus, where pain arousal abates almost as soon as shock has ceased, fear arousal from a loud noise may remain for many minutes despite the absence of further excitatory cues. Obviously, the greater is the spontaneous persistence of a given form of arousal, the greater is its capacity to influence motivation over

time. Third, intuitive analysis suggests that fear-reduction is a stronger motivational component than effectance-enhancement in a human shock-avoidance situation. The tenseness and accelerated heart-rate that one can expect to experience prior to R (e.g, lever-pressing) would surely predominate over the elation of anticipated success.

Extinction of Avoidance

While space does not permit a thorough application of the present theory to all aspects of shock avoidance, I foresee no major difficulty in such an effort. Consider the case of extinction. One of the most interesting facets of avoidance behavior has always been its extraordinary resistance to extinction (e.g., Solomon, Kamin, & Wynne, 1953; Solomon & Wynne, 1954). Not unlike traditional accounts of this phenomenon, the present theory posits that the fear excited by $\underline{s^{\bullet} \cdot c^{-}}$ and the channeling of regulation provided by $\underline{s^{\bullet} : r \cdot \bar{c}^{-}}$ produce such reliable avoidance responding that the organism's exposure to the new contingency $\bar{R}$—$\bar{C}^{-}$ is very rare during the early stages of the extinction situation. Once $\bar{R}$ begins, however, the organism soon learns the new conditional expectation $\underline{s^{\bullet} : \bar{r} \cdot \bar{c}^{-}}$, which in turn rapidly strengthens the motive for $\bar{R}$.

Another interesting facet of avoidance extinction is the fact that residual fear in the presence of $S^{\bullet}$ remains relatively high in animals during the period when $\bar{R}$ is commencing, whether that extinction is induced by conventional procedures (Kamin et al. 1963) or

flooding (Coulter, Riccio, & Page, 1969; Mineka & Gino, 1979; Page, 1955). It is significant that Hodgson and Rachman (1974, p. 321 [as quoted in Mineka and Gino, 1979]) report a similar pattern in clinical research on flooding with humans: "It would appear that the first beneficial effect of flooding is an ability to control unwanted responses at the behavioral level. Autonomic and subjective signs of distress, associated with non-avoidance, are then gradually extinguished over a period of days, weeks or months." The present theory suggests two probable evokers of fear during early extinction. First, the appearance of $S^{\bullet}$ should reactivate the rudimentary expectation $\underline{s^{\bullet} \cdot c^{-}}$. Second, the joint appearance of $S^{\bullet}$ and $\bar{R}$ should also reactivate the more sophisticated expectation $\underline{s^{\bullet} : \bar{r} \cdot c^{-}}$. Even though both expectations are now inaccurate, their activation should cause the common unit $\underline{c^{-}}$ to excite fear.

One might challenge the above account of extinction by asking why the existence of relatively strong fear arousal does not motivate an immediate resurgence in the rate of avoidance behavior. To answer this question, we must realize that fear's motivational function depends not only on the intensity of its arousal but also on how its regulative feedback is channeled. In the extinction situation, the growing predominance of the new conditional expectation $\underline{s^{\bullet} : \bar{r} \cdot \bar{c}^{-}}$ should draw surtainment away from the conditional expectation $\underline{s^{\bullet} : r \cdot \bar{c}^{-}}$. This in turn should strengthen the motive for $\bar{R}$ despite the existence of residual fear.

General Discussion

Emotion as a Hypothetical Construct

In assessing the present theory, one can begin by asking a fundamental question: Is its global conception of emotion a tenable hypothetical construct? Recall that emotion has been defined here as "a neural subsystem that primitively processes information in ways that differentially facilitate adaptive responses in the sensory, memory, and motor subsystems." The question is whether any evidence documents the existence of a psychological phenomenon corresponding to these global features. I believe that the construct has three lines of general support.

First, one can argue that the overall supportive conclusions drawn from the empirical review are genuinely relevant to the construct of emotion because most of the studies employed food and shock as primitive stimuli. As required by the definition, both of these stimuli convey information of substantial adaptive significance and elicit primitive motor responses that perform highly specialized adaptive functions. Thus, an approach to food and a withdrawal from shock both tend to promote individual and species survival. It is highly doubtful that the same pattern of results would have occurred if stimuli possessing less adaptive significance had been used.

Second, the empirical review presents substantial evidence that the functional relationship between such stimulus input and

response output is mediated by a distinct set of primitive transformational processes whose qualities are compatible with those specified in the present definition of emotion. One line of empirical support for this premise is the fact that these processes can function with memory to integrate contemporary information about a neutral stimulus' context with primitive information about the context's adaptive significance (e.g., Pavlov, 1927). These processes have also demonstrated a sophisticated capacity to produce generalization to stimuli possessing dissimilar sensory qualities but a common adaptive significance (e.g., LoLordo, 1967) and yet still produce discrimination between stimuli possessing similar sensory qualities but a different acquired adaptive significance (see the two tones used as $S^{\bullet}$ and S° in Rescorla and LoLordo [1965]). Finally, these processes have demonstrated a capacity to modulate the intensity of motor output in ways that often bear little or no relationship to the intensity of sensory input. A tone or light of moderate intensity, for instance, can have dramatic effects on the strength of an avoidance response.

Third, the required systematic nature of the mediating processes is manifested most clearly in the fact that their output exercises a powerful influence over their own subsequent input, as when they selectively facilitate the assimilation of gratifying food by promoting a novel bar-pressing response (e.g., Estes, 1948).

In light of these observations, it would be quite difficult to argue that emotion is an unnecessary and empirically unjustified construct. Some systematic process with special primitive energizing and directing functions clearly mediates between sensory input and motor output.

Empirical Status of Specific Principles

Moving on to issues about the precise nature of emotional processes, I believe that sufficient evidence has been presented to justify the preliminary postulation of almost all the theory's major principles of sequential differentiation. The only serious exception involves the principles of exertion feedback coding, and a sequel to the present article will marshall substantial support for that facet of the theory as well as other issues related to lateral differentiation.

Even so, one can readily see that the theory's overall empirical foundation is far from definitive. Many important questions remain partially or completely unanswered, and many methodological problems will need to be solved before all of the theory's principles can be adequately tested. But the historical development of our discipline, and of the more rigorous scientific disciplines as well, has repeatedly shown that methodology grows to meet theoretical demand. Just as Holmes (1974) would have been well served by more optimism in his assessment of the future possibilities for testing repression, we should refrain from prejudging the resources that may become available for testing any of the other aspects of the present theory. It is quite possible that the methodological elements for further verifying the theory's major postulates already exist and that they will yield valuable new information when properly exploited.

Thus, while it is true that autonomic indices of emotion have been

frought with many unexpected ambiguities (e.g., Ax, Note 4; Levi, 1967; Thayer, 1970), other promising techniques have yet to be methodically applied to the study of emotion due to the absence of a satisfactory guiding framework. A computer simulation of the theory, for example, could be used to generate quantitative predictions capable of comparison with existing mathematical models of such phenomena as Pavlovian conditioning (e.g., Rescorla & Wagner, 1972). Depth-electrode investigations (e.g., Berger & Thompson, 1977; Sideroff & Bindra, 1976) have only recently begun to analyze the complex sequential relationships between sensation, memory, emotion, and motor output during learning. Excellent opportunities also exist for developing a projective but empirically validated measure of mood, which could be used to great advantage in applying the present theory to social and clinical hypotheses (e.g., as a replacement for the reactive self-ratings employed by Pittman and Pittman [1979]). In a very real sense, then, the theory's testability is an empirical question about scientific behavior that can only be resolved by observing the methodological creativity that it elicits over time.

Theoretical Contribution

A colleague of mine once said: "I don't much care for the concept of emotion. It is too arbitrary. Some people use it to supply an ad hoc explanation for just about any behavior." Even though the present theory is certainly not free of predictive ambiguity, its reconceptualization of emotion within the rigorous

constraints of a systematic informational framework goes far toward reducing the flagrant arbitrariness to which my colleague was referring. The theory's specific analytical contributions can be summarized as follows:

1. Its interpretation of hedonic arousal as a complex mechanism for coding the adaptive significance of stimulation in terms of ancestral criteria clarifies emotion's evolutionary origins and functions without reverting to a simplistic nativism.

2. Its interpretation of hedonic arousal as laterally differentiated into seven distinct components provides a heuristic analysis of primitive motivational tendencies without succumbing to the temptation of proposing a different tendency for every type of behavior. (Note that contributions 1 and 2 owe a heavy debt to Plutchik [1980]).

3. Its conception of exertion feedback processes demonstrates how complex emotions like effectance and frustration can be understood as specialized responses to success and failure without having to postulate separate mechanisms for coding each of the myriad forms that success and failure can take.

4. Its interpretation of hedonic arousal and associative control as distinct but interrelated processes clarifies how information from personalized experience gains enormous influence over emotion without disavowing the former's postulated primitive constraints.

5. Its interpretation of trace regulation as a major deter-

minant of behavior clarifies emotion's critical contribution to motivation without blurring the valuable distinction between these two concepts. Motivation emerges as a complex process that depends equally on emotion and memory.

6. Its interpretation of regulation as a feedback process whose adaptiveness is ultimately evaluated and controlled by its effects on subsequent hedonic stimulation enables us to understand the underlying unity of behavior without losing sight of the latter's multiplicity of internal and external determinants.

Even if one accepts these contributions, however, the theory's unresolved empirical problems might prompt one to argue that it is shamefully profigate in its postulation of specific hypothetical mechanisms. Beyond a certain point, this criticism becomes a matter of philosophical preference. I believe that a theory capable of raising new issues within a systematic framework based on existing knowledge can have a highly beneficial effect even if some of its premises are highly speculative. Mowrer's (1947) two-process theory of avoidance is a case in point. Although that theory has proven faulty in some key respects, its emphasis on the motivational function of fear-reduction has served to inspire many fruitful investigations.

By contrast, an excessively cautious and parsimonious approach to theory has too often led to a prolonged period of minimally productive groping, as occurred with associationistic theory in early memory research (Jenkins, 1974). In addition to stifling

creative exploration, parsimony is a very ambiguous criterion even for assessing a theory's immediate explanatory power. A theory that appears parsimonious within the confines of a single research issue like shock avoidance in animals may prove quite unparsimonious when extended to logically related issues like the avoidance of visually threatening symbolic material (e.g., Luborsky, Blinder, & Schimek, 1965) and the avoidance of social affiliation (e.g., Sarnoff & Zimbardo, 1961) in humans. Thus, while Seligman and Johnston (1973) tried to use parsimony as a justification for the explanatory gaps and enigmas in their theory, they ignored the severe and unnecessary limitations in heuristic power that these flaws introduced.

The treatment of phobias provides an especially cogent example of the present theory's capacity to serve as a heuristic bridge between different areas of research. One of Bandura's classic studies has shown that dog phobias in children can be reduced merely by exposing subjects to a model's demonstration of non-avoidance without punishment (Bandura, Grusec, & Menlove, 1967). There is a close correspondence between the core informational elements presented to these subjects and the elements presented to subjects in a standard extinction paradigm, since both procedures display the relationship $\bar{R}$—$\bar{C}^-$ either directly or symbolically. Mere description of this correspondence is not particularly important because it has been noted before. But the explanatory power of Bandura's work has been impaired by his reliance on the theoretically ambiguous

notion of "reinforcement" in analyzing the motivational effects of such expectations as $\underline{r \cdot \bar{c}}$- (e.g., Bandura, 1971, 1977), since the necessary causal mechanisms in this construct have never been rigorously explained. By rectifying that deficiency, the present theory can help us to better understand the common mediational processes involved in observational and participant forms of avoidance learning. Similar applications are suggested by Murray and Jacobson's (1978) analysis of other contemporary psychotherapeutic procedures. Nevertheless, there will need to be a sizable expansion of the theory's treatment of cognitive processes (especially of inference and self-evaluation) before such prospects can reach their full fruition. See Stratil (Note 2) for an effort in that direction.

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Footnotes

[1]The term "arousal" was selected for its present usage because it connotes intensity, duration, primitiveness, and emotionality. Although some writers have used it to refer to autonomic activity, the present usage has no such implication. Hedonic arousal is an assimilative process located entirely in the central nervous system, whereas autonomic activity is an expressive process in the peripheral nervous system.

[2]Note, however, that the present theory does not fully reject the concept of reciprocal inhibition between opposing centers. I have already proposed, for example, that fear may be inhibited by several forms of pleasure. But I essentially interpret reciprocal inhibition as secondary to, and less powerful than, the direct associative inhibition that was originally proposed by Konorski. In addition to empirical arguments such as those presented by Rescorla, one of my principal justifications for this premise is intuitive. Personal experience suggests that fear can coexist with pleasure (e.g., during a daring exploit one may experience fear toward the dangers involved yet simultaneously experience effectance from interpretations of one's preliminary success). A strong inhibitory reflexive connection between effectance and fear would preclude such a combination.

[3]Although unconventional, these and related notations have been adopted in the present article because they mesh with the

larger terminological framework that I am developing for the study of attitudes (Stratil, Note 2).

[4]These terms are introduced to rectify several defects in conventional terminology. Byrne's (1961) use of sensitization to refer to a focusing of attention on threatening information is too narrow, since sensitization is a broader process that essentially involves any lowering of a structure's response threshold to a particular type of stimulus. Vigilance, by contrast, focuses more narrowly on attentional processes and better expresses one's underlying motive, which to prepare oneself to cope with the stimulus. At the other end of the dimension, Byrne's use of repression can be considered too narrow because the total process that attenuates threat-assimilation is based on denial and stimulus avoidance as well as repression. Constriction more clearly conveys this breadth. Like vigilance, it also denotes a broad attentional function.

[5]The term sensitization is used here in its generic sense to indicate a decrease in a unit's activation threshold rather than to indicate associative sensitization, which is a special case of that process.

[6]The fact that an S° for loud noise failed to reduce the rate of shock-avoidance in LoLordo's (1967) study might be interpreted as contradicting the above inference. But this failure can be attributed to the continuing, concurrent presence of the Sidman

avoidance schedule during Pavlovian training. According to the present theory, the avoidance situation as a whole should have maintained mild but non-zero levels of fear despite the systematic pairing of S° with noise absence. Therefore, S° was never really paired with fear reduction. The fact that this failure did not occur with shock as C^{-} can be attributed to shock's greater probable salience and to its greater relevance to critical expectations.

Figure Captions

Figure 1. Schematic representation of the hypothetical hedonic arousal component. (Features 1, 2, 3, and 4 depict input, while features 5, 6, 7, and 8 depict output.)

Figure 2. Schematic representation of the hypothetical exertion feedback component. (Exertive tension codes the occurrence of exertion, as manifested by cues from intentional motor expression [1] and intentional short-term memory activity [2]. Increases in exertive tension [3] initiate the coding of anticipatory hedonic arousal [4], while decreases in such tension [5] or the occurrence of intentional motor suppression [6] initiate the coding of consummatory hedonic arousal [7]. When the comparison of anticipatory and consummatory arousal is favorable, a primitive success cue is generated [8]. An unfavorable comparison generates a primitive failure cue [9].)

Figure 3. Schematic representation of the hypothetical associative control component, as it functions in fear. (The presence of shock, C^- [1], produces an increase in pain's hedonic arousal [2], which initiates sensitization [3] of the excitatory fear register [4] and causes an association [5] to develop between that register and the trace $\underline{c^-}$. Later pairing of a presence cue, $S^\bullet$, with shock produces the expectation $\underline{s^\bullet \cdot c^-}$ [6], which is capable of independently exciting [7] fear's hedonic arousal structure. Since absence of the shock, $\overline{C^-}$ [8], is paired with decreases in pain's hedonic arousal

[9], this event causes the inhibitory fear registration [10, 11, and 12] of the trace $\underline{\bar{c}^-}$. Later pairing of an absence cue, $\dot{S}^o$, with $\bar{c}^-$ enables the expectation $\underline{\dot{s}^o \cdot \bar{c}^-}$ [13] to transmit an inhibitory stimulus [14] to fear's hedonic arousal. These associative control processes can also be initiated by changes in fear's own hedonic arousal [15 and 16].)

Figure 4. Schematic representation of the hypothetical regulative component. (Facilitators of pleasure and impeders of distress receive excitatory regulative feedback. Impeders of pleasure and facilitators of distress receive inhibitory feedback.)

Figure 5. Schematic representation of the hypothesized motivational responses to a presence cue in Rescorla and LoLordo's (1965) shock-avoidance experiment. (Preliminary operant training caused the expectation $\underline{\bar{r} \cdot c^-}$ [1], which cognized that non-avoidance was followed by shock, to acquire the capacity to excite [7] fear's hedonic arousal structure. Such training also caused the expectation $\underline{r \cdot \bar{c}^-}$ [2], which cognized that avoidance was followed by no-shock, to acquire the capacity to inhibit [10] fear arousal. Further Pavlovian and operant training then caused $\underline{\dot{s}}$, the trace for the presence cue, to become directly associated to $\underline{c^-}$ [6], $\underline{\bar{r} \cdot c^-}$ [12], and $\underline{r \cdot \bar{c}^-}$ [11]. As a result, a subsequent appearance of the presence cue alone was able to initiate a complete sequence of avoidance responding. That is, its excitation of fear arousal caused the regulative component to transmit surtainment [8] to the

fear-inhibiting expectation $\underline{r \cdot \bar{c}^-}$, which facilitated performance of R [9]).

Figure 6. Schematic representation of the hypothesized motivational responses to an absence cue in Rescorla and LoLordo's (1965) shock-avoidance experiment. (Pavlovian pairing of an absence cue [1] with no shock [2] produced the expectation $\underline{s^o \cdot \bar{c}^-}$ [3], which was capable of inhibiting fear [4] without activating $\underline{r}$. Subsequent exposure to the absence cue alone therefore inhibited fear and reduced avoidance-facilitating surtainment [5]. Since the resulting non-avoidance [6] was then paired with no-shock [2] during exposure to the absence cue [1], the organism developed the conditional expectation $\underline{s^o : \bar{r} \cdot \bar{c}^-}$ [7 and 8]. This expectation then enabled the absence cue to further weaken the avoidance response by redirecting surtainment toward $\bar{r}$ [9]).